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LIQUID CRYSTAL DISPLAY DEVICE  
[Ekisho hyoji sochi]

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## Claims

1. A liquid crystal display device characterized by the following facts: the liquid crystal display device has a liquid crystal cell and a pair of polarized plates set on the outer sides of the liquid crystal cell, respectively; the liquid crystal cell is prepared as follows: on the opposite surfaces of a pair of glass substrates, a pair of transparent electrodes crossing each other and orienting films covering the transparent electrodes are formed, respectively, and a liquid crystal material is sealed in between the orienting films; in this liquid crystal display device, a phase difference compensating element is arranged on the opposite surface side of at least one glass substrate of said liquid crystal cell.

2. The liquid crystal display device [described in Claim 1] characterized by the fact that said phase difference compensating element is a twisted phase plate with liquid crystal polymer molecules in twisted orientation.

## Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a liquid crystal display device of twisted nematic type.

[0002]

Prior art

As the liquid crystal display device for use as display in word processor, personal computer, etc., the TFT-TN type liquid crystal display device is in use. As shown in Figure 3, for this liquid crystal display device, polarizer (2) is arranged on the light incident side (lower side) of twisted nematic (TN) type liquid crystal cell (1), and analyzer (4) is arranged via phase plate (3) on the light exit side (upper side)

of liquid crystal cell (1). Said liquid crystal cell (1) has a pair of upper/lower glass substrates (5), (6). On the upper surface of glass substrate (5) on the lower side, one-side electrodes (7) and driving thin films (TFT) (8) set in various pixels of said electrodes (7) as well as orienting film (9) are formed. On the lower surface of glass substrate (6) on the upper side, other-side electrodes (10) set crossing said one-side electrodes (7) and orienting film (11) covering said other-side electrodes (10) are formed. Here, said upper/lower glass substrates (5), (6) are bonded to each other with a prescribed spacing between them by means of sealant (12) arranged on the peripheral portion. Then, liquid crystal material (13) is sealed in the region defined by said sealant (12) and said glass substrates (5), (6). Said analyzer (2) on the lower side of liquid crystal cell (1) has its transmissive axis arranged orthogonal to the orienting treatment direction of orienting film (9) on the lower side of liquid crystal cell (1), and it is set on the lower surface of glass substrate (5). Said analyzer (4) on the upper side of liquid crystal cell (1) has its transmissive axis arranged almost perpendicular to the transmissive axis of analyzer (2) and is set on phase plate (3) on the upper surface of glass substrate (6) on the upper side. Also, phase plate (3) is arranged for compensating for the difference in phase difference between the light that passes liquid crystal cell (1) obliquely and the light that passes perpendicularly. As said phase plate (3), one may make use of a uniaxial phase plate or a biaxial phase plate, or the like. It is formed in film form, and, with its phase delay axis correctly positioned, it is bonded on the upper surface of glass substrate (6) on the upper side.

[0003]

Problems to be solved by the invention

However, for the aforementioned TN type liquid crystal display device in the prior art, because phase plate (3) is manufactured separated from liquid crystal cell (1), the number of parts is larger, and phase

plate (3) has to be bonded on liquid crystal cell (1), so that the manufacturing process becomes complicated, and the productivity is poor. This is undesired. The purpose of the present invention is to solve the aforementioned problems of the prior art by providing a liquid crystal display device that can reduce the number of parts, simplify the manufacturing operation, and improve the productivity.

[0004]

Means to solve the problems

The invention described in Claim 1 is characterized by the fact that a phase difference compensating element is arranged on the opposite surface side of at least one glass substrate of the liquid crystal cell. The invention described in Claim 2 is characterized by the fact that a twisted phase plate is used, and, for the twisted phase plate, the liquid crystal polymer molecules as the phase difference compensating element in twisted orientation.

[0005]

Operation

According to the present invention, a phase difference compensating element is arranged on the opposite surface side of one-side glass substrate of the liquid crystal cell, so that the phase difference compensating element can be integrated to the liquid crystal cell. As a result, it is possible to reduce the number of parts and to simplify the manufacturing operation. Especially, as described in Claim 2, as the phase difference compensating element, a twisted phase plate having organic polymer in twisted orientation is used, so that it is possible to compensate the difference in phase difference of the transmitted light of the liquid crystal cell, and it is possible to improve the coloration of display and the field of view's angle characteristics.

[0006]

#### Application examples

In the following, an explanation will be given regarding an application example of the present invention. In this case, the same symbols as those in the above in the prior art are adopted, and they will not be explained again. For the liquid crystal display device, on the lower surface of glass substrate (6) on the upper side of liquid crystal cell (1), twisted phase plate (20) is arranged. On the upper surface of glass substrate (6) on the upper side, analyzer (4) is directly arranged. The other features are the same as those in Figure 3. That is, on the lower surface of glass substrate (6) on the upper side, twisted phase plate (20) set via orientation treatment film (21), and protective film (22) is formed covering said twisted phase plate (20). On the lower surface of said protective film (22), other-side electrodes (10) facing and crossing one-side electrodes (7) and orienting film (11) covering said other-side electrodes (10) are formed. In this case, for twisted phase plate (20), a liquid crystal polymer is coated on the lower surface of orientation treatment film (21), the liquid crystal polymer molecules are oriented and defined by orientation treatment film (21), so that the structure is twisted oriented regularly in the prescribed direction.

[0007]

For the liquid crystal display device, because twisted phase plate (20) is arranged on the lower surface of glass substrate (6) on the upper side of liquid crystal cell (1), twisted phase plate (20) can be manufactured in the same step of operation simultaneous to glass substrate (6) of liquid crystal cell (1). For example, first of all, the orienting material is coated on the lower surface (opposite surface) of glass substrate (6), and orientation treatment film (21) is formed by performing orienting treatment. On this

film, a liquid crystal polymer is printed, and twisted phase plate (20) is formed. On this plate, protective film (22) is printed and laminated. Then, transparent electrodes (10) are formed by vapor deposition. As a result, it is possible to reduce the number of parts and to simplify the manufacturing process, so that the productivity is improved. Especially, for twisted phase plate (20), the liquid crystal polymer is coated on orientation treatment film (21) arranged on the lower surface of glass substrate (6). As a result, the molecules are twisted oriented regularly in the prescribed direction due to definition by orientation treatment film (21). Consequently, there is no need to align the phase delay axis as would be needed in the prior art when it is bonded on the outer side. As a result, the productivity is excellent. Also, because twisted phase plate (20) has the molecules in twisted orientation, there is no need to arrange plural phase plates because the field of view characteristics of the uniaxial phase plate are improved over that of the prior art. It is possible to compensate the difference of the phase difference generated in liquid crystal cell (1) almost completely by a single [phase plate], and the field of view characteristics are improved.

[0008]

In the aforementioned application example, explanation has been made on the case of TN type liquid crystal display device. However, the present invention is not limited to this scheme. The present invention may also be adopted in the liquid crystal display device that adopts the simple matrix driving system of the super twisted nematic (STN) type. In this case, on the inner surface (opposite surface) of one of a pair of substrates set facing each other with a prescribed spacing between them, the liquid crystal polymer is coated, and the molecules are in twisted orientation to form a twisted phase plate. On this twisted phase plate, electrodes and orienting film are sequentially laminated via a protective film. On the inner surface of the other substrate, electrodes are arranged crossing said electrodes, and an

orienting film is laminated. Here, between the orienting films of the pair of substrates, the liquid crystal material is sealed such that the molecules are twisted oriented at an angle of about  $240^\circ$  from one substrate to the other substrate. On the outer sides of a pair of substrates, a polarizer and an analyzer are arranged in a prescribed arrangement. For this STN type liquid crystal display device, in order to enable high time division driving, the twist angle of the liquid crystal molecule configuration is increased, and, in order to increase the contrast of the viewing angle, the birefringence effect of the liquid crystal is used. Consequently, display is colored, and this is undesired. However, by arranging a phase plate as the color compensating element, it is possible to remove coloration of the display. Consequently, according to this invention, as it is adopted on the STN type liquid crystal display device, it is possible to manufacture, at a high productivity, the STN type liquid crystal display device with display coloration eliminated.

[0009]

In the above, explanation has been made of the liquid crystal display device for black and white display in said application example. However, the present invention is not limited to this scheme. For example, as shown in Figure 2, the present invention may also be adopted in the case of a color liquid crystal display device. In this case, on the upper surface of glass substrate (5) on the lower side of liquid crystal cell (1), color film (24) and protective film (25) covering said color film (24) are simultaneously formed beforehand. On the upper surface of protective film (25), one-side electrodes (7) and thin film transistors (8) arranged on the various pixels of said one-side electrodes (7) as well as orienting film (9) covering them are formed. In this color liquid crystal display device, too, the same operation and effects as the aforementioned application example also can be realized.



[0010]

#### Effects of the invention

According to the invention described in Claim 1, a phase difference compensating element is arranged on the opposite surface side of a one-side glass substrate of the liquid crystal cell, so that the phase difference compensating element can be integrated with the liquid crystal cell. As a result, it is possible to reduce the number of parts and to simplify the manufacturing operation and thus to improve the productivity. According to the invention described in Claim 2, as the phase difference compensating element, a twisted phase plate with liquid crystal polymer molecules in twisted orientation is used. Consequently, when STN type liquid crystal display device is used with a single twisted phase plate, it is possible to compensate the difference in phase difference for light at various wavelengths generated in the liquid crystal cell almost completely, and the display coloration can be improved. For the TN type liquid crystal display device, the field of view's angle characteristics can be improved.

#### Brief description of the figures

Figure 1 is a cross-sectional view illustrating an application example of the liquid crystal display device of the present invention.

Figure 2 is a cross-sectional view illustrating a modified example of application of the present invention in the color liquid crystal display device.

Figure 3 is a cross-sectional view illustrating the liquid crystal display device in the prior art.

#### Explanation of symbols

- 1      Liquid crystal cell
- 2      Polarizer

- 4 Analyzer
- 5 Glass substrate on the lower side
- 6 Glass substrate on the upper side
- 7, 10 Electrode
- 9, 11 Orienting film
- 20 Twisted phase plate
- 21 Orientation treatment film

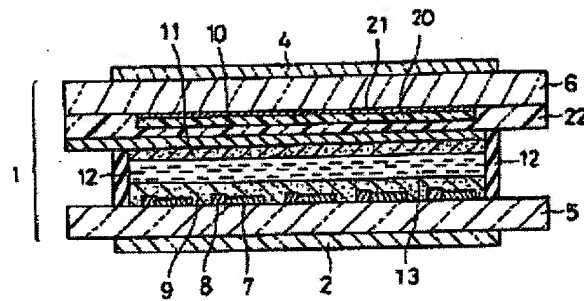


Figure 1

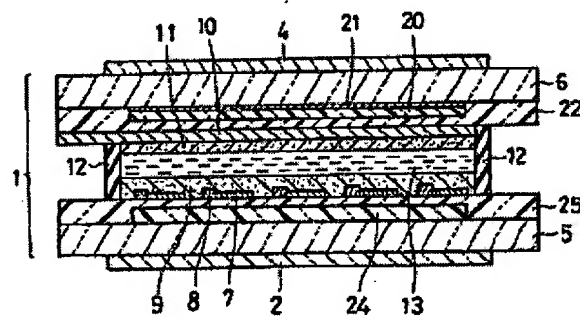


Figure 2

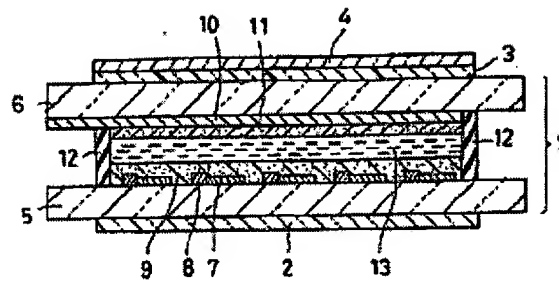


Figure 3